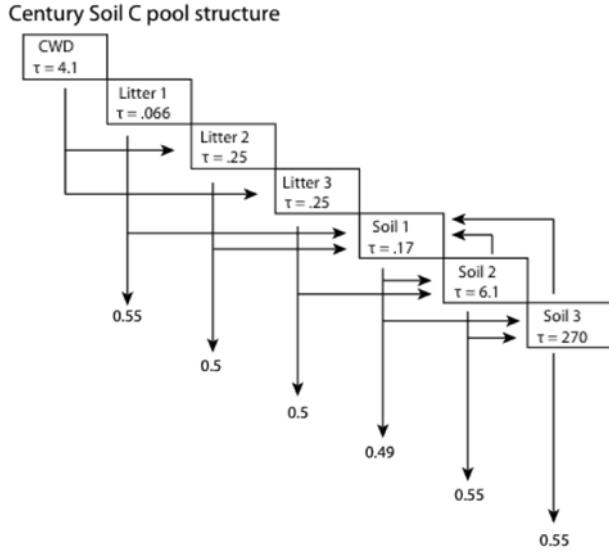


## The Soil decomposition model in CLM



CWD=coarse wood debris; Litter1 is the metabolic pool (i.e., soluable sugars), Litter2 is the celuose; Litter 3 is the lignin pool. The governing equation in CLM is as followings (Koven et al 2013),

$$\frac{\partial C_i(z)}{\partial t} = R_i(z) + \sum_{j \neq i} (1 - r_j) T_{ji} k_j(z) C_j(z) - k_i(z) C_i(z) + \frac{\partial}{\partial z} \left( D(z) \frac{\partial C_i}{\partial z} \right) + \frac{\partial}{\partial z} (A(z) C_i) \quad (3)$$

, where carbon content  $C_i$  is now defined volumetrically ( $\text{kg C m}^{-3}$ ), plant inputs  $R_i$  ( $\text{kg C m}^{-3} \text{ s}^{-1}$ ) are distributed over the profile, decomposition constant  $k_i$  is defined at each model level, and we add an advective-diffusive soil C transport component, with diffusivity  $D$  ( $\text{m}^2 \text{ s}^{-1}$ ) and advection  $A$  ( $\text{m s}^{-1}$ ). The vertical dimension requires three new sets of

To simplify the process, let us ignore the advection process. Namely, set  $A(Z)=0$ . The vertical transportation is mainly based on diffusion with  $D(z)$  set at  $5 \text{ cm}^2/\text{year}$  for active layer, and linearly decrease from the base of the active layer to zero at a set depth (default 3m).

The parameters of baseline decomposition and transformation are specified in the following table:

Transition Pools	$T_{ji}$	$r_j$
Century-based		
CWD → L2	0.76	0
CWD → L3	0.24	0
L1 → S1	1	0.55
L2 → S1	1	0.5
L3 → S2	1	0.5
S1 → S2	f(txt)	f(txt)
S1 → S3	f(txt)	f(txt)
S2 → S1	0.93	0.55
S2 → S3	0.07	0.55
S3 → S1	1	0.55

The conversion from soil pool 1 to soil pools 2 and 3 are dependent on the soil texture properties. It is calculated using the following three equations,

$$t = 0.85\_r8 - 0.68 * 0.01 * (100 - \%Sand)$$

$$T_{12} = 1.0 - .004 / (1.\_r8 - t)$$

$$T_{13} = .004\_r8 / (1.0 - t)$$

The baseline decomposition rate is modified by the following environmental factors:

$$k_i = k_{0,i} r_T r_w r_O r_z, \quad (4)$$

where  $k_{0,i}$  is the intrinsic turnover time for each pool ( $\text{yr}^{-1}$ ; Table 1),  $r_T$  is the temperature rate modifier,  $r_w$  is the moisture modifier,  $r_O$  is the oxygen modifier, and  $r_z$  is the depth modifier (all the modifiers are dimensionless scale factors).

The effect of soil water potential is calculated as follows,

$$r_w = \frac{\log\left(\frac{\psi_{\min}}{\psi}\right)}{\log\left(\frac{\psi_{\min}}{\psi_{\max}}\right)}, \quad (5)$$

where  $r_w$  is the rate scalar for moisture limitation, equal to 0 below  $\psi_{\min}$  and 1 above  $\psi_{\max}$ , with  $\psi_{\min} = -10 \text{ MPa}$  and  $\psi_{\max}$  equal to the saturated soil matric potential. The  $Q_{10}$

The explicit temperature dependence of soil water matric potential below the freezing point uses the supercooled water formulation of Niu and Yang (2006) is as follows,

$$\psi(T) = -\frac{L_f(T - T_f)}{10^3 T} \quad (6)$$

where  $L_f$  ( $\text{J kg}^{-1}$ ) is the latent heat of fusion, and  $T_f$  (K) is the freezing temperature of water. Thus the total temperature limitation below the freezing point is equal to the product of the  $Q_{10}$ -based direct limitation and the temperature-dependent moisture limitation. For  $\psi_{\min}$  of  $-10 \text{ MPa}$  in Eq. (5), this formulation predicts zero respiration rates below  $-8^\circ\text{C}$ .

The temperature effects is simulated based on Q10 (=1.5) function as follows,

$$r_{tsoil} = Q_{10}^{\left( \frac{T_{soil,j} - T_{ref}}{10} \right)} \quad (7)$$

where  $j$  is the soil layer index,  $T_{soil,j}$  (K) is the temperature of soil level  $j$ . The reference temperature  $T_{ref} = 25^\circ\text{C}$ .

The depth factor is calculated as follows,

$$r_{depth} = \exp\left(-\frac{z}{z_\tau}\right)$$

where  $z_\tau$  is the e-folding depth for decomposition, set by default to 0.5m.

At this stage, let us ignore the oxygen effect. Namely,  $r_o=0.0$ .